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EVALUATION OF SMOKE DETECTORS IN HOMES

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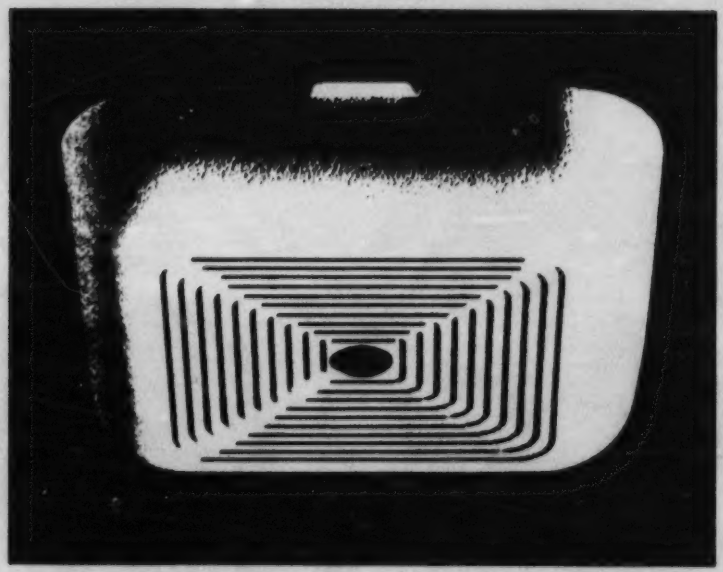

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federal emergency
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EVALUATION OF SMOKE DETECTORS IN HOMES

INTERIM REPORT - PHASE I

Federal Emergency Management Agency
U.S. Fire Administration

Prepared for
National Fire Data Center
Home and Public Building Safety Division

By
David B. Gratz and Raymond E. Hawkins
International Association of
Fire Chiefs Foundation

May 1980

FEDERAL EMERGENCY MANAGEMENT AGENCY
Washington D.C. 20472

This report represents the first major effort to evaluate the effectiveness of residential smoke detectors under actual field conditions. I congratulate the Task Force and Project Staff of the International Association of Fire Chiefs Foundation for their excellent contribution.

The conclusions and observations of this report should be of great assistance to fire officials wishing to receive public support in obtaining smoke detector legislation. Although additional studies will be conducted, this report represents a valuable beginning.

Gordon Vickery
Administrator
U.S. Fire Administration

READEX FICHE

ACKNOWLEDGEMENTS

This study was performed under direction of a Project Task Force designated by the Executive Committee of the International Association of Fire Chiefs Foundation. Members are:

John F. Hurley, Task Force Chairman
President, IAFC Foundation

Thomas C. Hayden, Chief
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The project was directed by David B. Gratz, Executive Director of the Foundation, Raymond E. Hawkins served as Associate Investigator and Patricia M. Collins provided the administrative services.

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Minneapolis, MN - Captain Eugene H. Klesmit

Montgomery County, MD - Assistant Chief James F. Dalton

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EXECUTIVE SUMMARY

Fire officials are generally strong advocates of smoke detectors in residential property. This advocacy is based on their belief that a significant number of lives will be saved if only the occupants are given earlier warning of potentially life threatening fires. Because of this concern fire officials have been in the forefront of efforts to develop and encourage legislation mandating smoke detectors. This position requires that these fire officials have sufficient research and experience to adequately support their recommendations to both public and elected officials.

Fire officials do have available a number of studies providing useful performance data on smoke detectors. However, most studies to date have been directed toward specific issues or limited to a particular jurisdiction. While these reports are helpful, fire officials desiring to obtain public support for smoke detectors must also be able to provide information relating to performance of smoke detectors in actual or noncontrolled fire incidents.

The primary objective of this study, therefore, is to examine how smoke detectors are performing when an unwanted fire occurs in residential property under actual or noncontrolled conditions. Another objective was to collect data on smoke detectors that might be helpful in determining the need for or direction of future research into smoke detector performance.

This report includes data collected through January, 1980 covering 1168 incidents attended by fire departments in 12 jurisidictions throughout the United States. Included in these incidents are 699 unwanted fires, 256 incidents resulting from smoke caused by friendly fires and 213 incidents from other causes. There were a total of 1589 smoke detectors in the incidents reported to date.

The investigation of incidents and reporting of data were carried out by experienced fire officers using a standard reporting format and uniform guidelines. In addition, each report was carefully reviewed prior to data processing. The objective was to achieve the highest possible degree of consistency, especially where the investigators were being asked to make a judgement.

Based on the data collected to date, a number of conclusions and observations are evident.

1. The study indicates that smoke detectors are providing earlier warning to potentially life threatening situations. Investigators determined that an alarm from a smoke detector provided the first warning in over 40% of the unwanted fire situations. In the majority of incidents it was the occupant initially alerted however, in some instances the first warning of an unwanted fire was received by a neighbor or passerby. This earlier warning is essential to life safety and reduced property loss.

2. Investigators estimated that a smoke detector alarm reduced the potential for serious injury or death in 27% of the 699 unwanted fires examined during this study. This potential for reducing serious injury or death increased to 90% when all occupants were asleep. These results pertain only to the incidents investigated in this study and therefore should not be applied to national statistics for all fire incidents. Regardless, the results do indicate that the earlier warning provided by smoke detectors is having an impact in reducing the loss of life and serious injury in residential property.

3. Smoke detectors are also having a frequent impact on reducing the fire loss to property. Investigators in the communities studied estimated that fire loss was reduced in approximately 35% of the unwanted fire incidents due to the earlier warning provided by the smoke detector. This finding would seem

to be especially important to insurers of property.

4. The initial intent of this study was to focus on unwanted fire incidents. The rationale was that unwanted fires, those not intended or desired by the occupant, would represent the greatest potential threat to life safety and property loss. These unwanted fires do present the greatest threat. However, smoke from fires or heat sources even if confined to their intended place of origin may also be a threat. An example would be smoke from a blocked fireplace chimney. Although the extent to which a smoke detector alarm reduced loss of life and property in these incidents is less than for unwanted fires, the reduction in loss of life and property is nevertheless significant. This suggests that in future studies data might better be organized to distinguish between threatening and nonthreatening incidents regardless of cause.

5. The vast majority of smoke detector installations in the communities studied can be described as one single station, ionization detector installed by the owner/occupant of the residence sometime in the past 3-4 years. This appears to correspond closely with the widespread code adoption effort mandating detectors and the intensive marketing program carried out by manufacturers.

6. Using current nationally accepted criteria, investigators judged that 94% of all smoke detectors were correctly installed and 92% of the detectors were properly located in the residence. Most detectors were installed by the owners using manufacturers' instructions. This is encouraging. Manufacturers and fire organizations that have developed instructional materials should be pleased with this positive result.

7. Approximately 40% of the detectors in this study had been periodically tested. The failure to test 60% of detectors did not appear to cause increased failures in detector activation. However, since most detectors are relatively new (3-4 years) it is probably too early to evaluate the long range service, maintenance and performance implications of failing to periodically test detectors in accordance with recommended procedures. This is an area requiring additional study.

8. A long-standing issue with smoke detectors is that of sensitivity. Smoke detectors may on occasion alarm from causes other than an unwanted fire. On the other hand, smoke detectors may also fail to activate when they should. In the first instance the unneeded alarm is usually a minor annoyance, and one which many residents have come to accept. In the latter case the problem, failure to alarm when it should, is more serious and more complex.

In the communities studied, investigators found that there was no apparent alarm from an installed smoke detector in 225 or 32% of the unwanted fires. Although some of these failures were due to installation or power problems, the majority of these failures were attributed to lack of sufficient smoke at the detector location to cause activation. More specific identification of why these detectors did not alarm was beyond the scope of this study. Since this judgement was usually made sometime after the fire, it is subjective. There is no way to verify the investigators' assumptions or to determine if the smoke detector(s) were sufficiently sensitive to function as they should. This is certainly an area requiring further study.

Although there have been several useful studies concerning smoke detector performance the majority have dealt with hypothetical situations or have been limited in scope. The objective of this study was to examine smoke detector performance in residential properties on a broader scale and during actual fire incidents. The results of this study support other research efforts which strongly indicate that smoke detectors in residential property are saving lives, preventing injuries and reducing fire losses. This type of empirical evidence is especially important to fire officers who must justify their support for smoke detector legislation or regulations.

I. INTRODUCTION

Since the mid-1970's there has been a phenomenal increase in the manufacture, sale, and use of smoke detectors in residences. The widespread public acceptance of smoke detectors as a means to reduce the loss of lives from fire in residences has occurred for several reasons. These include strong advocacy by fire officials; legislation mandating detectors at the federal, state and local levels; proposals for tax and fire insurance incentives and an intensive marketing effort. However, with the rapid increase in the use of detectors, the question of smoke detector reliability and effectiveness has become an important issue, especially for fire officials who must support their recommendations with more than opinion.

BACKGROUND

The recent interest in smoke detectors is evident from the large increase in sales of smoke detectors since 1971 (1). This sales growth appears to be a result of extensive advertising campaigns by the fire service and the media, and legislation mandating their installation.

Local and state ordinances vary considerably in their requirements for smoke detectors in residential properties (2). These regulations may be applicable to a wide range of conditions including new construction, newly leased or purchased units, and even retroactive requirements applicable to all existing units.

Current editions of the various model building codes include requirements for smoke detectors which have now been adopted by numerous jurisdictions. The United States Fire Administration has reported:

> As of October 1978, 22 states and the District of Columbia had adopted mandatory smoke detector laws for new residential construction. Five states and the District of Columbia also required smoke detectors in existing residential structures under selected conditions. Seven other states had enacted smoke detector legislation, but these laws are either a recommended guide only or require additional legislative action at the local level for the provisions to apply. Twenty-one states had no smoke detector laws, though at the time of the study at least nine state legislatures were considering such measures.(8)

In addition to local and state legislation, the Federal Housing Administration stipulates that for residences to be eligible for federally supported financing they must be equipped with a minimum of one smoke detector (2).

Promotions and retail sales advertising have also been influential in smoke detector sales. In one survey, the Aerospace Corporation estimated that almost one-third of all smoke detectors were purchased as a result of motivation obtained from advertising (1).

Regardless of the reason a large number of smoke detectors have been purchased. Between 1971 and 1976 annual sales of smoke detectors climbed from approximately 897,000 to over 12,000,000 units per year. As a result the Aerospace Corporation concluded that over 33,000,000 detectors were in American residences at the time of their study.

RESEARCH NEEDS AND PROBLEMS

It is reasonable to expect that as the number of detectors increases, there should begin to be a reduction in certain types of fire deaths and injuries. Some preliminary research indicates that smoke detectors are a factor in preventing loss of life and property. However, there remains a lack of organized empirical research to fully support the benefits of detector equipment. Even with the extensive amount of laboratory technical data, actual field performance of smoke detectors in non-controlled situations has not been evaluated in an organized manner.

As interest and publicity increased, so too have questions. Fire officials are frequently asked to recommend detection equipment and to provide advice on installation and maintenance. The public is especially interested in information relating to actual performance of detectors. Fire officials desiring to obtain support for detector legislation can expect the need to justify their requests to both legislators and the public with information relating to actual performance of detectors, in addition to citing the results of laboratory research.

If support for detectors is to continue, and hopefully increase, it is essential that fire officials and organizations be able to respond to inquiries with the assurance that their recommendations and comments are valid. When recommending legislation it is especially important that the fire chief in each community have available reliable performance data upon which legislation can be recommended and to assist in developing public support.

Economic considerations comprise part of the fire officials' documentation of the overall effectiveness of smoke detectors to the public and other government officials. The expense of a single smoke detector is relatively minimal. However, purchase of a large quantity required for an apartment complex, can be substantial. Benefit/cost analyses have been presented considering hypothesized reductions in potential life and property losses due to smoke detectors (11). However, additional analysis will be useful and necessary to overcome the arguments of potential critics.

These issues indicate that there is a need for additional information about what residential detectors can do in the effort to save lives and property. This project is an organized effort to fill the knowledge gap and thereby serve as a contribution to efforts to improve life safety and reduce fire losses.

STUDY METHODOLOGY

The data for this study was gathered from actual incidents in residences which were protected by at least one smoke detector. Fire department officers provided the data in accordance with specific instructions by completing a special survey from provided for that purpose. (See Appendix).

Initially three jurisdictions were selected for a pilot test of instructional materials, the data collection form and the training procedures conducted by Foundation staff members. The three jurisdictions participating in the pilot test were Dallas, TX, Toledo, OH and Montgomery County, MD. Minor modifications were made to the instructions and form as a result of the pilot test.

Upon completion of the pilot test, nine additional jurisdictions were identified for participation in the data collection. The criteria for selection of the cities included the requirements that they have an on-going reporting system that would be compatible with national systems and that they have local legislation mandating smoke detectors. In addition, preference was given to jurisdictions that could carry out the reporting using a limited number of personnel. Since some questions required subjective responses it was desired to keep the number of reporting individuals to a minimum. This would reduce training problems and increase consistency in the reporting. Data collection in the additional jurisdictions began as soon as training could be accomplished. The jurisdictions included in the study and the dates they began data collection are shown in Table 1.

Incidents were selected for reporting if all of the following three criteria were fulfilled:

1. The fire incident occurred in a residential property.

2. At least one smoke detector was installed in the residential property.

3. The fire department responded to the fire incident. (Note: incidents were included only if they were classified as fire-related emergencies, thus excluding all medical-related and other non-fire-related emergencies.)

See the Appendix for further information on these criteria.

It should be noted that activation of a smoke detector in the residential unit involved in the incident is *not* required for the incident to be included in the study. In an attempt to obtain a variety of data on smoke detector installations the USFA requested that incidents be included

even if no fire department action was required upon their arrival.

Fire department officers were requested to complete the data form promptly after the incident. These reports were then forwarded to Foundation Headquarters where they were numerically coded according to a pre-determined coding system. The coding of the information prepared the data for computer analysis.

TABLE 1

NUMBER OF INCIDENTS REPORTED BY JURISDICTIONS
(Through January 31, 1980)

Jurisdiction	Reporting Began	Unwanted Fires	Smoke Friendly Fire	Other	Total
Anne Arundel County, MD	July 1979	6	0	0	0
Arlington County, VA	June 1979	20	4	5	29
Aurora, CO	June 1979	18	3	1	22
*Dallas, TX	November 1978	61	42	42	145
Fairfax, VA	July 1979	3	2	0	5
Minneapolis, MN	May 1979	3	0	0	3
*Montgomery County, MD	January 1978	309	164	97	570
Portland, OR	April 1979	109	7	1	117
Prince George's County, MD	June 1979	25	2	0	27
Rockford, IL	June 1979	17	4	0	21
*Toledo, OH	November 1978	88	15	8	111
Virginia Beach, VA	April 1979	40	13	59	112
	TOTAL	699	256	213	1168

*Pilot test jurisdiction

DEFINITIONS USED IN THE STUDY

The large number of jurisdictions and individuals participating in the collection of data required a common set of definitions by which incidents could be classified.

In order to distinguish between potentially threatening fire incidents and other incidents, the Task Force established these definitions for classifying incidents:

"*Unwanted Fire*" - an undesired fire, destructive to life or property (sometimes referred to as a hostile or unfriendly fire.)

"*Smoke From a Friendly Fire*" - a friendly fire is a fire in its intended or properly confined space, such as a fireplace, furnace or stove. However, even though the fire is properly confined smoke may escape in sufficient quantity to activate a smoke detector.

"*Other*" - any activation of a smoke detector not classified above. Examples include activation from steam, temperature change, low battery warning signal, etc.

The primary objective of these definitions was to provide a distinction between incidents that were a threat and those which were more in the nuisance category. For the most part these definitions were adequate. However, the study has revealed that there are a number of incidents classified under "Smoke From a Friendly Fire" which may also threaten life and property. For this reason a modification of these definitions will be made prior to future data collection.

II. IMPACT OF SMOKE DETECTORS ON VARIOUS INCIDENTS

The primary objective of this study is to assess the extent to which smoke detectors reduce the loss of life and property damage from unwanted fires in residential buildings. Therefore, this study sought to identify residential fires which represent the greatest potential threat to life and property.

Initially it had been assumed that the unwanted fire incident would be the greatest threat to loss of life and property. Although this proved to be the case, it is apparent that some incidents classified as "Smoke From a Friendly Fire" also represent a potential threat and therefore deserve analysis.

Fire departments also respond to a variety of other incidents where a smoke detector may be installed and may even have activated from various causes. Since it was determined that these other incidents could also be reported without significant additional burden, data was collected covering a number of questions related to smoke detector performance and installation. Therefore, jurisdictions were requested to report every fire-related incident in residential property where a smoke detector was installed, even if the detector did not activate. Several tables have been included to provide an overview of all incidents.

The number of incidents reported by each jurisdiction through January 31, 1980 is shown in Table 1. The distribution of these incidents by residential property classification is provided in Table 2. The reported point of origin within the residence is shown in Table 3. Finally, Table 4 provides a distribution of all incidents by time of day.

The remainder of this section is divided into three parts. First, is an analysis of smoke detector performance in those incidents where an unwanted fire occurred. The second part will discuss performance in those incidents involving smoke from friendly fires and finally data on other incidents is provided.

TABLE 2

NUMBER OF INCIDENTS REPORTED BY PROPERTY CLASS

Property Class	901 Code	Unwanted Fires	Smoke, Friendly Fire	Other	Total
One or Two Family Dwelling	419	515	193	162	870
Apartments, Tenement	429	167	61	49	277
Rooming, Boarding House	439	2	1	0	3
Hotel, Motel, Inn	449	12	0	1	13
Dormitories	469	2	0	0	2
Not Classified	499	1	1	1	3
	TOTAL	699	256	213	1168

Residential properties are classified according to the 901 coding format of the National Fire Protection Association.

TABLE 3

INCIDENTS BY AREA OF ORIGIN

Area of Origin	Unwanted Fires		Smoke, Friendly Fires		Others	
	No.	%	No.	%	No.	%
Chimney	8	1.1	3	1.2	0	0.0
Closet	10	1.4	0	0.0	0	0.0
Entrance Way	3	0.4	0	2	2	0.9
Ext. Balcony	8	1.1	0	0.0	0	0.0
Garage	10	1.4	0	0.0	1	0.5
Hallway	4	0.6	1	0.4	121	56.8
Heating Equip.	57	8.2	63	24.6	9	4.2
Int. Stairs	0	0.0	0	0.0	31	14.6
Kitchen	256	36.6	133	52.0	11	5.2
Laundry	22	3.1	7	2.7	3	1.4
Lavatory	14	2.0	0	0.0	3	1.4
Lounge Area	140	20.0	44	17.2	14	6.6
Roof Assembly	8	1.2	0	0.0	0	0.0
Sleeping Area	100	14.3	0	0.0	12	5.7
Storage Area	38	5.5	1	0.4	4	1.8
Miscellaneous	21	3.1	4	1.5	2	0.9
TOTAL	699	100.0	256	100.0	213	100.0

* National Fire Protection Association 901 Code

TABLE 4

INCIDENTS BY TIME OF DAY

Time by Hour	Unwanted Fires		Smoke Friendly Fires		Other	
From-To	NO.	%	NO.	%	NO.	%
0001-0200	39	5.6	13	5.1	17	8.0
0200-0400	38	5.4	5	1.9	10	4.7
0400-0600	24	3.4	6	2.3	14	6.6
0600-0800	34	4.9	14	5.5	18	8.5
0800-1000	64	9.2	21	8.2	30	14.1
1000-1200	72	10.3	29	11.3	20	9.4
1200-1400	80	11.4	27	10.5	16	7.5
1400-1600	90	12.9	37	14.5	16	7.5
1600-1800	67	9.6	34	13.3	11	5.1
1800-2000	94	13.4	37	14.5	28	13.1
2000-2200	47	6.7	19	7.4	15	7.0
2200-2400	50	7.2	14	5.5	18	8.5
TOTAL	699	100.0	256	100.0	213	100.0

SMOKE DETECTOR PERFORMANCE DURING UNWANTED FIRES

In order to evaluate the impact of smoke detectors during unwanted fires, it is necessary to first determine occupancy, status of occupants, and whether detectors are activating.

Occupancy at Time of Incident

Investigators found that 596 (85%) of the residences were occupied at the time of an unwanted fire incident. The number of occupants in the residence varied considerably as the study includes all types of residential properties as shown in Table 2. In summary, 455 (76%) of the occupied residences had three or less occupants, 129 (22%) had between four and nine occupants, and twelve (2%) had ten or more occupants at the time of an unwanted fire incident.

Status of Occupants

Investigators were asked to determine whether occupants were awake or asleep at the time of the incident. In some incidents, there were occupants in both categories.

Incidents with all occupants awake	437	73%
Incidents with all occupants asleep	124	21%
Incidents with some occupants awake/asleep	35	6%
	596	100%

Considering that only 101 (14%) of the unwanted fires were reported between midnight and 0600, it is not especially surprising to find that at least one occupant was awake in the majority of incidents.

Detector Activation

At least one smoke detector activated in 474 (68%) of the 699 unwanted fires. The alarm was the:

First Warning Provided to Occupants	224 Incidents
First Warning Provided to Others	60 Incidents
Detectors Alarmed, But Was Not First Warning	190 Incidents
	474 Incidents

In 284 (60%) of the 474 incidents when a smoke detector activated, the alarm was the first warning of an unwanted fire. In the other 190 (40%) incidents, the initial warning came from another source, i.e. occupant smelled smoke before the detector actually alarmed or a passerby observed smoke.

In the 284 incidents where a smoke detector did provide the first warning, it was to the occupant of the residence in 224 (79%) of the incidents. The remaining 60 (21%) of the incidents resulted in another person hearing the alarm, i.e. neighbor or passerby.

It is significant that in the 224 incidents where a smoke detector provided the first warning to an occupant that at least one occupant was awake in 161 (72%) of these incidents. This finding will be of interest to smoke detector advocates whose main argument has been that the primary value of smoke detectors is to awaken sleeping residents. The results of this study indicate that smoke detectors may also be as important in providing early warning even where an occupant is awake.

A smoke detector failed to activate in 225 (32%) of the 699 unwanted fire incidents. There were a total of 390 smoke detectors found installed in the 225 incidents.

It was not within the scope of this study to specifically identify the reasons why smoke detectors failed to alarm. Such an assessment was not possible due to the nature of the data collection design and more importantly, the lack of testing equipment which is required. Nevertheless, investigators were asked to provide a reason for a failure when it was obvious (no battery), or at least a generalized judgement.

Of the 390 smoke detectors that failed to activate there were 268 (73%) detectors where the

investigator was of the opinion that there was insufficient smoke at the detector location to cause activation. For example, an unwanted fire occurred in a room with the door closed preventing smoke from spreading to a detector located elsewhere in the residence.

It must be emphasized that the classification of insufficient smoke was frequently a judgement made after the fire and may not always be valid. In some cases investigators who found a detector which was apparently operational (by using a test button to activate alarm) assumed that there had not been sufficient smoke at the point where the detector was located. However, investigators seldom had an opportunity to witness first hand the extent of smoke. In addition, investigators were not equipped to conduct sensitivity tests of detectors to determine if they actually were operational as distinct from being able to sound the alarm when the test button was used.

As previously stated, the question of sensitivity is not within the scope of Phase I of this study. However, the fact that over 23% of the failures to activate in the 699 unwanted fire incidents is attributed to insufficient smoke indicates the importance of examining the issue of sensitivity in Phase II.

In addition to the failures reported to be from insufficient smoke, there were 122 other smoke detectors which failed to activate during an unwanted fire. Although a reason was not reported for 27 of these detector failures, investigators were able to determine why the other 95 smoke detectors did not activate. The reasons reported were:

No Batteries	37
Incorrect Location	22
No A/C Power	13
Incorrect Installation	12
Dead Battery	8
Faulty Detector	3
	95

The 122 smoke detectors that should have activated represent only 13% of the total number of smoke detectors installed in the unwanted fire incidents. Although one hundred percent performance would be desirable, this rate of failure attributed to mechanical or human problems is perhaps less than might be expected.

Smoke Detector Impact on Loss of Life and Property

The purpose of this study is to assess whether smoke detectors will provide earlier warning to occupants who could be threatened by an unwanted fire. Fires which are allowed to grow unchecked increase the chances that occupants may not be able to escape. Any delay in warning also increases the damage to both building and contents. Therefore early warning is important, if not critical, to life safety and property protection.

The data collected for this study indicates that the alarm from a smoke detector was the first warning in 284 (41%) of the 699 unwanted fire incidents. The issue is whether these earlier warnings had any impact in saving lives or reducing property loss.

Although is it difficult to accurately measure an event that is prevented or one that does not occur, investigators were asked to give an opinion on the impact the early warning had on reducing loss of life and damage to property. This opinion was developed through personal observation and in most cases discussion with the occupant(s). The following summarizes the opinions and conclusions reached by the investigators for the 699 unwanted fire incidents:

Number of Unwanted Incidents with Likelihood of Reduced Death or Serious Injury

Certain	—	71	10%
Probable	—	116	17%
		187	27%

Number of Unwanted Incidents with Likelihood of Reduced Property Loss

Considerable Reduction	133	19%
Some Reduction	113	16%
	246	35%

Note: These data pertain only to the incidents investigated in this study and may not be suitable for comparison with results of other studies.

In the unwanted fires studied to date, smoke detectors did not alarm in 225 incidents. The majority of these nonactivations were attributed to insufficient smoke. It is impossible to evaluate whether these detectors should have alarmed or if they had alarmed whether that would have provided earlier warning of a situation that was a potential threat to life or property. This again indicates the need to further study why some detectors are not activating when an unwanted fire occurs.

If the number of incidents in which there was some reduction in property loss is measured only against the 474 unwanted fires where a detector actually alarmed, then the percentage of potentially reduced property loss increases from 35% (699 unwanted fires) to 52% and for potentially prevented loss of life the percentage increases from 27% to 39%.

The value of smoke detectors is even more apparent when the performance is tested against the 224 unwanted incidents where the smoke detector alarm provided the first warning to occupants of the residence, especially if all residents were asleep.

Smoke detectors provided the first warning in 140 incidents where at least one occupant was awake. Investigators reported that death or injury were prevented in 74 (53%) of these incidents and that property loss was reduced in 108 (77%) incidents. However, these percentages increase dramatically in the 63 incidents where all occupants were asleep. For these incidents the perceived reduction in death or injury was 95% and a reduction in property loss in 95% of these incidents.

SMOKE DETECTOR PERFORMANCE DURING FRIENDLY FIRES

The previous section dealt with incidents involving unwanted fires. Data for these incidents was collected and analyzed separately in the belief that it is the unwanted fire which represents the greatest potential threat to life and property damage. Incidents of smoke from friendly fires were also analyzed.

Cooking fires, fireplaces, stoves, etc., create smoke even though the fire itself remains confined to its intended location. In most instances smoke generated from these friendly fires is more of a nuisance than a threat. However, data collected for this study indicates that smoke from so-called friendly fires may also threaten lives and result in damage to property.

As an example, in one incident the occupant closed the fireplace damper before retiring, thinking the fire was completely extinguished. During the night hot coals in the ashes caused the fire to re-kindle. Even though the fire remained confined to the fireplace, the closed damper forced the smoke into the house. Investigators were of the opinion that there was sufficient smoke to cause a fatality. Fortunately, the smoke detector activated in time for the occupant to escape without serious injury.

In another incident, a smoke detector alerted the occupant to smoke from food burning on the stove. Although this incident did not threaten a life, the earlier warning was reported to have reduced the extent of property damage which would have resulted from the excessive smoke. These are but two examples of incidents which, even though classified as "friendly," represented a potential threat to the loss of life or injury and damage to property.

For the 1168 incidents covered in this study, 256 (22%) were classified as Smoke, Friendly Fire. A smoke detector activated in 180 (70%) incidents and provided the initial warning in 107 (42%) of these 265 incidents. If these 107 alarms are evaluated based solely on the 180 incidents

where a smoke detector actually alarmed, then initial warning was provided by a smoke detector in 60% of the incidents classified as "Smoke from Friendly Fires". These are summarized:

First Warning Provided to Occupants	89
First Warning Provided to Others	18
Detectors Alarmed, But Was Not First Warning	73
TOTAL	180

Although the extent to which these alarms reduced loss of life and property is less than for incidents involving unwanted fires, the results for friendly fires are also significant. See Table 5.

As with the unwanted fire incidents previously discussed there was a significant number of these incidents where at least one occupant was awake. Incidents with at least one occupant awake and receiving the first warning totaled 75 (84%) of the 89 incidents listed above.

SMOKE DETECTOR PERFORMANCE DURING OTHER INCIDENTS

In addition to alarms caused by unwanted fires and smoke from friendly fires, there were 213 incidents investigated in the study that were classified as "other." Data for these incidents was collected as part of the study's secondary objective of obtaining information that could assist in determining what additional research might be useful. The distribution of the 213 incidents was:

Detector Malfunction	119	56%
Low Battery Alarm	51	24%
Uncertain	43	24%
	213	100%

TABLE 5

COMPARISON OF REDUCED LIFE AND PROPERTY LOSS

Unwanted Fires vs. Friendly Fires

(Incidents Where Smoke Detector Activated)

	Unwanted Fires		Smoke, Friendly Fires	
REDUCTION IN LOSS	No.	%	No.	%
Considerable	133	28	15	8
Some	113	24	34	19
None	228	48	131	73
	474	100%	180	100%
REDUCTION IN DEATH/INJURY				
Certain	71	15	9	5
Probable	116	24	27	15
Doubtful	287	61	144	80
	474	100%	180	100%

Investigators used the classification of "detector malfunction" wherever a detector alarmed for no apparent reason. No attempt was made to determine the cause. There were 51 incidents resulting from a low battery signal. Although this is a relatively small number it still indicates the need for manufacturers and fire officials to better educate occupants in what a low battery alarm sounds like and what they should do about replacing the batteries. The reason for alarms in 43 incidents was not clearly stated.

More specific data concerning smoke detector performance is provided in the next chapter.

SUMMARY

The data obtained in this study supports the claims of fire officials that smoke detectors can save lives. Even when occupants are awake smoke detectors are providing early warning which is alerting occupants to potentially life threatening situations. In those incidents where all occupants were asleep the life saving potential increases very significantly in the event of an unwanted fire.

The primary objective of this study was to investigate unwanted fires under the assumption that they represent the greatest potential threat. While this assumption proved correct it is also apparent that smoke from "friendly fires" may also be threatening. Even though the fire or source of heat may remain confined to its intended location smoke emissions may be sufficient to create a hazard.

The early warning provided by smoke detectors is also resulting in a considerable reduction in loss of property. In the past fire officials have emphasized the life safety benefits in their efforts to encourage smoke detectors. It would be well to also place additional emphasis on the value of smoke detectors in reducing property losses. Insurance companies especially should be made aware of this finding and be requested to give additional recognition to the value of smoke detectors when establishing rates for residential properties.

III. SMOKE DETECTOR DATA

A secondary objective of this study was to collect data on the types of smoke detectors in use, installation practices and to assess the extent to which occupants periodically test their smoke detectors. In some cases this data was collected regardless of the type of incident and irrespective of performance.

TYPE OF SMOKE DETECTORS

There were a total of 1589 smoke detectors included in the 1168 incidents covered in this report. The types, power sources and wiring arrangements are summarized in Tables 6 through 8.

TABLE 6

DETECTOR TYPE

Type	Number	Percent
Ionization	1361	86
Photoelectric	204	13
Combination Ion/Photo	21	1
Not Reported	3	0
TOTAL	1589	100%

TABLE 7

DETECTOR POWER SOURCE

Power Source	Number	Percent
Battery	1046	66
AC Direct Wire	434	27
AC Plug-in	68	4
AC/Battery Combination	40	3
Not Reported	1	0
TOTAL	1589	100%

TABLE 8

DETECTOR WIRING SYSTEMS

Type	Number	Percent
Single Station	1500	94
Interconnected	89	6
TOTAL	1589	100%

Two-thirds of all residences in this study were found to have only one smoke detector installed. This was not especially surprising as nearly 75% of all residential units in this study were one or two family dwellings (see Table 2) where one smoke detector would usually be sufficient to meet the minimum requirements for these jurisdictions.

DETECTOR INSTALLATION

Tables 9 through 13 provide a variety of data relative to the installation of smoke detectors.

Of the 1589 smoke detectors found in this study, 934 (59%) were installed by the owner or occupant and 421 (26%) installed by a contractor. The remaining 234 (15%) were installed by others, usually defined as friend, relative or maintenance personnel. Not unexpectedly, installations by occupants tend to be battery-type units whereas the majority of direct-wired AC installations were made by contractors. The percentage of installations for the AC plug-in unit was fairly evenly divided between occupant and contractor.

Who installed a smoke detector is not as important as whether it was correctly installed and properly located. For both installation (mounting or connecting) and location (placement) the results were extremely encouraging. Over 94% of all detectors were correctly mounted, wired and connected in accordance with manufacturer's instructions. Approximately 91% of all detectors were found to be properly located in the residence. This judgement was based on the criteria recommended to provide a minimum level of protection. (See Appendix.)

The data indicates that correct installation and proper placement are relatively independent of who makes the installation. A reasonable assumption is that the instructional materials provided by manufacturers and recommendations by fire officials are adequate and that they are being followed in most cases.

TABLE 9

DETECTOR INSTALLATION

Installer	Number	Percent
Owner	934	59
Contractor	421	26
Other	234	15
TOTAL	1589	100%

TABLE 10

ADEQUACY OF DETECTOR INSTALLATION

Correct Installation	Number	Percent
Yes	1499	94
No	90	6
TOTAL	1589	100%

"Correct Installation" refers to whether smoke detectors were correctly mounted, wired, connected, etc. in accordance with manufacturers' recommendations.

TABLE 11

YEAR OF INSTALLATION

Year	Number	Percent
1965	1	0.1
1970	4	0.2
1972	7	0.4
1973	4	0.2
1974	12	0.8
1975	18	1.1
1976	125	8.0
1977	335	21.1
1978	542	34.1
1979	127	8.0
Not Reported	414	26.0
TOTAL	1589	100.0%

TABLE 12

ADEQUACY OF DETECTOR LOCATION

Location	Number	Percent
Correctly Located	1454	92
Incorrectly Located	135	8
TOTAL	1589	100%
Incorrect Locations:		
Not Leading to Sleep Area	85	
Not at Top of Stairs	27	
Improper Distribution (More than one detector)	19	
Not in Sleeping Area	4	
TOTAL	135	

"Correct location" refers to whether smoke detector(s) were located for maximum protection in accordance with accepted recommendations.

TABLE 13

SPECIFIC LOCATION OF DETECTORS

Where Located	Number	Percent
Hallway	1004	63.2
Interior Stairs	289	18.2
Sleeping Area	92	5.8
Lounge Area	70	4.4
Kitchen	42	2.6
Supply Storage Area	26	1.6
Dining Area	21	1.3
Entrance Way	11	0.7
Other	10	0.7
Heating Equipment Area	9	0.6
Laundry Area	6	0.3
Storage Area, Other	3	0.2
Closet	2	0.1
Garage	2	0.1
Lavatory	1	0.1
Office	1	0.1
TOTAL	1589	100.0%

DETECTOR TESTING

Fire officials and manufacturers recommend that smoke detectors be tested at least once a month. Many smoke detectors include a light or button for testing. However, this may only verify that power is present or that the alarm will sound. They seldom, if ever, test sensitivity. Therefore, testing with actual smoke is recommended. Table 14 reports the results found in this study.

Only 636 (40%) of the smoke detectors were reported to have been tested in the month prior to the incident. Even that number could be exaggerated as some occupants may be reluctant to admit they did not test their detectors. Nearly one-half of the detectors 774 (49%) were not tested. The remaining 179 (11%) were not reported and quite possibly could be included as not tested.

The test performed on 305 (48%) detectors included the use of smoke as recommended. The remaining 322 (51%) detectors were tested using the test button. More than 83% of all tests were performed by the occupant.

The rate of testing appears to be somewhat higher in those residences where the detector was installed by the occupant. This may result from more identification with the detector when installed personally. It may also mean that a person who actually installs a smoke detector may be more exposed to instructional materials on care and maintenance. Fire officials should consider the need for a different type of educational or instructional technique for individuals who did not do the initial installation and therefore may not have the instructions available. This need will become increasingly apparent as smoke detectors become a more common part of a residence, thereby being taken for granted.

TABLE 14

WAS DETECTOR TESTED WITHIN 30 DAYS

Tested	Number	Percent
Yes	363	40
No	774	49
Not Reported	179	11
TOTAL	1589	100%
Test Method:		
Test Button	322	
Smoke	255	
Both Button and Smoke	50	
Other	9	
TOTAL	636	

INTERNATIONAL ASSOCIATION OF

FIRE CHIEFS FOUNDATION

APPENDIX

PROCEDURES

for Completing the

RESIDENTIAL SMOKE DETECTOR REPORT

February 15, 1979

1329 18th Street, N.W. • Washington, D. C. 20036 • (202) 833-8323

RESIDENTIAL SMOKE DETECTOR REPORT

The purpose of the Residential Smoke Detector Report (RSDR) is to provide data on how smoke detectors are performing in actual every day situations. When combined with laboratory test data, the actual field experience will provide valuable information on the effectiveness of smoke detectors in residential properties.

WHEN TO COMPLETE

The RSDR must be completed for every fire related incident in residential property where a smoke detector is found to be installed, even if the detector did not activate. The RSDR need **not** be completed on rescue, ambulance, special service or other non-fire related incidents.

Ideally the RSDR should be completed at the time of the incident, or shortly thereafter in order to obtain the most current and most accurate information.

WHO SHOULD COMPLETE

In order to maintain the maximum consistency in the reports, the number of individuals completing the RSDR should be limited. The pilot test of the form and procedures indicated that good results could be obtained by having the RSDR completed either by a fire investigator or a district chief while they were completing their routine reports. Except in very small departments, use of company officers to complete the reports is discouraged due to training problems and the large quantity of reports that must be stocked.

REPORTING MULTIPLE FAMILY (UNIT) BUILDINGS

As a general rule the report should cover a single family residence or the single living unit within a multiple family structure. As an example, the report for an incident in one apartment within a building where there are 100 apartments would only cover the one apartment or what may be referred to as the *unit of origin*. However, in multiple family structures the investigator must exercise judgement in how to report the incident.

In multiple family structures where the incident is clearly confined to the unit of origin and other units were not effected either directly or indirectly, it is sufficient to report only for the unit of origin. Under the "remarks" section it would be desirable to add some comment such as: "This building includes a total of 100 living units all equipped with detectors but no others activated".

On the other hand let us assume that although the fire was confined to the unit of origin, smoke traveled throughout the bulding activating many other detectors. (Trash room or hallway fires could also activate many alarms.) The investigator must decide whether the other alarms affected life safety to a degree they should be reported individually or as a group.

If detectors activate in areas or units other than the space where the fire originated and that alarm results in alerting occupants who would otherwise not be alerted in time to escape, then each unit (detector) should be reported separately. If other detectors activate but do so after the occupants have already been evacuated or notified by other means (internal building alarm) then a narrative comment on what took place should be sufficient.

There can be no hard and fast rules for reporting incidents in multiple family structures. The investigator must use judgement.

INSTRUCTIONS FOR COMPLETING THE RESIDENTIAL DETECTOR REPORT (RSDR)

Please follow this guide in completing the RSDR.

INCIDENT NO.

Enter the incident number assigned by your department. This number must coincide exactly with the number on the Fire Incident Report used by your department.

DATE

Enter month, day, year of incident.

TIME

Enter time of initial alarm, using 24 hour clock.

901 PROPERTY CLASSIFICATION

Enter 901 Code number designating type of residential property:

419 - Dwelling, one and two family

429 - Apartments, Tenements, Flats, three or more units

439 - Rooming, Boarding, Lodging House

449 Hotels, Motels, Inns, Lodges

469 - Dormitories

499- Residential Property not classified above (explain).

TYPE OF INCIDENT

Your regular Fire Incident Report will normally provide specifice information on the "Type of Incident." Therefore the RSDR only requires reporting one of three broad categories:

"Unwanted Fire" - an undesired fire, destructive to life or property. (Sometimes referred to as "hostile" or "unfriendly fire".)

It is anticipated that the vast majority of incidents where the fire department will be notified will be classified under the heading of "Unwanted Fire". Frequently the occupant will not call the fire department when a smoke detector activates if it is a situation in which the occupant does not feel threatened. Example, smoke from cooking (except grease) or in a fireplace. However the fire department may be called in these cases and these incidents should be classified in one of the following:

"Smoke From a Friendly Fire" - a "friendly fire" is a fire in its intended or properly confined space such as a fireplace, furnace or stove (except grease). However, even though the fire is properly confined smoke may escape in sufficient quantity to activate a smoke detector.

"Other"- use for any activation of a smoke detector not classified above. Examples include activation from steam, temperature change, low battery warning signal, etc.

In every case please enter a description of the incident. Be brief but specific. Examples:

"Mattress fire"

"Base and contents"

"Smoke from fireplace"

"Steam from shower"

"Weak battery alarm"

WAS RESIDENCE OCCUPIED

Indicate whether persons were actually in the residence at time of the initial alarm. Report how many persons and whether they were awake or asleep. If some persons were awake and some asleep, estimate how many of each category.

TOTAL NUMBER OF DETECTORS

Insert the total number of detectors regardless of whether they activated. Complete Section II on reverse side of form. Spaces have been provided to permit entering information on two (2) detectors. If there are more than two (2) detectors, simply record on extra RSDR's and staple to original. To insure proper identification, the extra RSDR should have all information completed in top section.

COMPLETING SECTION I.

This section should be completed if a detector(s) activated. Questions include:

1. Which detector(s) alarmed?

2. Was the detector the **first** indication of fire or smoke? If the detector alarm did result in the first notice, then who initially heard the alarm? If it was not an occupant, then "x" "Other" and explain who; e.g. a neighbor, passerby, etc.

3. and 4. Require a judgement decision. This is especially true in evaluating whether

fire loss was reduced as a result of earlier warning than would have been expected had the detector not sounded an alarm.

Remarks - the remarks section should be used to add supporting or explanatory information. For example, if the detector was not first to alert the occupants yet ultimately alarmed, describe why the detector was late in alarming.

COMPLETING SECTION II - DETECTOR SPECIFICATIONS

The majority of information in this section is self-explanatory, simply check appropriate box or enter information as requested.

Model number - in many installations the model number cannot be readily obtained without removing the detector. In these cases you may omit model number. However, if there appears to have been a malfunction in the detector the model or serial number is important and should be included.

There are two questions on installation and location. The question on installation is intended to cover the technical, mechanical or legal requirements of smoke detector installation. The question on "location" is to evaluate if the detector is located so as to provide maximum protection. For example, a single detector in a two story house might be correctly installed but incorrectly located if it was in the basement rather than outside the sleeping area on the second floor.

Under "Is Detector Correctly Installed?" note whether the detector appears to be installed to manufacturer's direction, applicable codes or accepted practice. If not, indicate why, e.g. "too close to corner in dead air space", "improper wiring", etc.

Under "Location of Detector", describe where detector is located; e.g. "Second floor hall outside bedrooms", "Top of basement stairway", etc. Be brief but sufficiently specific. Check whether detector is mounted on ceiling or wall.

"Is Smoke Detector Properly Located?" is an effort to determine if the detector was placed in accordance with accepted recommendations provided in NFPCA publications *Smoke Detector Training,* GPO-003-000-00529-1, and *Smoke Detector Technology,* GPO-003-000-00526-7 and/or NFPA 74.

RESIDENTIAL SMOKE DETECTOR REPORT

Reporting Department	Date	Completed By

Incident No.	Mo	Day	Year	Time	901 Residential Property Classification

Type of Incident: ☐ Unwanted Fire ☐ Smoke From Friendly Fire ☐ Other _____

Briefly Describe Incident: _____

Was Residence Occupied at Time of Incident? ☐ Yes ☐ No If "Yes" Number of Occupants at Time of Incident _____ Were Occupants ☐ Awake ☐ Asleep

How many smoke detectors were installed in this residence? _____

Did one of these detectors activate on this incident? ☐ Yes ☐ No

If "Yes" please complete Section I below and provide the information for each detector in Section II on the reverse side of this form. If there were more than two (2) detectors use another RSDR.

If "No" disregard Section I and only complete Section II on the reverse side.

Section I

1. Which detector(s) activated (alarmed)? ☐ No. 1 ☐ No. 2 ☐ Both

2. Did detector alarm result in the *first* notification of a fire or smoke? ☐ No ☐ Yes

   If "Yes", who was first alerted? ☐ Occupant ☐ Other _____

3. It is ☐ Certain ☐ Probable ☐ Doubtful that the smoke detector alarm resulted in preventing the death or serious injury to _____ (number) persons.

4. The warning provided by the smoke detector alarm is estimated to have resulted in ☐ Considerable ☐ Some ☐ No reduction in the fire loss.

Remarks: _____

(over)

25

Return to:
International Association of Fire Chiefs Foundation
1329 18th Street, N.W.
Washington, D.C. 20036
(202) 833-8323

Revision 3

Section II

DETECTOR NO. 1

Type: ☐ Ionization ☐ Photoelectric ☐ Comb. Photo./Ion. ☐ Single Station ☐ Interconnected

Manufacturer _____ Model No.: _____

Power Source: ☐ Battery ☐ AC Plug-In ☐ AC Direct Wire ☐ Combination AC/Battery

Installed: Month _____ Year _____ By: ☐ Owner ☐ Contractor ☐ Other _____

Is Detector Correctly Installed? ☐ Yes ☐ No If "No", Explain _____

Where is Detector Located? _____ Where is Detector Mounted? ☐ Ceiling ☐ Wall

Does this Location Comply With Accepted Practices? ☐ Yes ☐ No

If "No", Explain _____

Was Detector Tested in Last 30 Days? ☐ No ☐ Yes By: ☐ Occupant ☐ Maintenance Personnel ☐ Fire Dept. Personnel ☐ Other _____

If "Yes," How Was Test Made? ☐ Button ☐ Smoke ☐ Both ☐ Other _____

Did this detector activate on this incident? ☐ Yes ☐ No. If "No" which of the following applies:

☐ This detector was improperly located.

☐ This detector was properly located but smoke at this location was insufficient to cause activation.

☐ Sufficient smoke was present at detector location but it failed to alert due to:

☐ No Batteries ☐ No AC Power ☐ Incorrect Installation ☐ Other

Comments: _____

DETECTOR NO. 2

Type: ☐ Ionization ☐ Photoelectric ☐ Comb. Photo./Ion. ☐ Single Station ☐ Interconnected

Manufacturer _____ Model No.: _____

Power Source: ☐ Battery ☐ AC Plug-In ☐ AC Direct Wire ☐ Combination AC/Battery

Installed: Month _____ Year _____ By: ☐ Owner ☐ Contractor ☐ Other _____

Is Detector Correctly Installed? ☐ Yes ☐ No If "No", Explain _____

Where is Detector Located? _____ Where is Detector Mounted? ☐ Ceiling ☐ Wall

Does this Location Comply With Accepted Practices? ☐ Yes ☐ No

If "No", Explain _____

Was Detector Tested in Last 30 Days? ☐ No ☐ Yes By: ☐ Occupant ☐ Maintenance Personnel ☐ Fire Dept. Personnel ☐ Other _____

If "Yes," How Was Test Made? ☐ Button ☐ Smoke ☐ Both ☐ Other _____

Did this detector activate on this incident? ☐ Yes ☐ No. If "No" which of the following applies:

☐ This detector was improperly located.

☐ This detector was properly located but smoke at this location was insufficient to cause activation.

☐ Sufficient smoke was present at detector location but it failed to alert due to:

☐ No Batteries ☐ No AC Power ☐ Incorrect Installation ☐ Other

Comments: _____

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